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ASSESSING THE CONCENTRATION OF BACTERIOLOGICAL CONTAMINANTS IN GROUNDWATER: EVIDENCE FROM THE WA MUNICIPALITY OF GHANA

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ABSTRACT

The essentiality of water makes it purposeful for both domestic and industrial usage. Similarly, the assertion that water is bound from contamination is untrue if not tested. The purpose of this study is to establish the concentration of bacteriological contaminants in ground water in the Wa Municipality of Ghana. The study is an experiment of six (6) sample units which include: 3 boreholes, 2 Wells and a sample from the GWCL reservoir. The findings from the study found that all the parameters tested – Total Coliform, Faecal Coliform and Escherichiacoli were high beyond the WHO benchmarks in five sample units with the exception of GWCL (0.0 cfu/100 ml)which was within recommendation. As a result, the test was significant ($p \leq 0.05$) at two tail test. Signaling that the concentration of bacteriological contaminants in groundwater from five experimented samples with the exception of GWCL sample were highly concentrated and poses health threat because the samples undergoes little treatments.

***KEYWORDS:** Water Quality, Groundwater, Bacteriological Contaminants, Wa Municipality & Ghana*

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Original Article

INTRODUCTION

Background

Water is one of the essentials that support all forms of plant and animal lives (VanLoon & Duffy, 2005). Naturally, most groundwater originates as meteoric water from precipitation in the form of rain or snow (Adombire, 2007).However, it is underscored that water has unique chemical properties due to its polarity and hydrogen bonds which means it is able to dissolve, absorb, adsorb or suspend many different compounds (WHO, 2007). In this view, water can be said to be an essential commodity which its importance and necessity cannot be underestimated in any form. Thus, the quality of any water regardless of its use should be well considered before it is accepted for the desired purpose. As such due to heavy rains, pollution of groundwater can be influenced by percolation of pesticides and by animal and human waste which stimulate variation of groundwater in quality and quantity seasonally (Nagarajan *et al.,* 2012). Mendie (2005) stressed that in nature water is not pure as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities. Presupposing that water quality assurance management system is core to safeguarding the essentiality that water provide to its elements (i.e. plants and animals). According to Briggs (1996) quality is said to be the totality of characteristics of an entity that bear on its ability to satisfy stated and implied need whereas assurance refers to the provision of adequate confidence that an entity will fulfill requirements for quality. WMO (2006) refers quality assurance (QA) as the overall management of a sampling programme so that reliable and accurate data are produced. This in effect would provide a reconnaissance for

effective monitoring of water bodies especially groundwater due to its unsusceptible characteristics of higher purity.

Notwithstanding, research on the subject area has been broadly tackled by varied researchers both in academia and public discourse from the global perspective to Ghana specific. On the global perspective, numerous research have centered on surface and groundwater pollution, their research found that there are contaminants in groundwater as a results of industrial, agricultural and municipal activities (Vidal *et al*.,2000; Lee *et al*., 2001; Oguzie *et al.*, 2002; Speir *et al.*, 2003; Razo *et al*., 2004).On the regional scale, many studies have concentrated much to assessing the levels of heavy metals in water from groundwater (boreholes) predominantly in mining communities with little focus on bacteriological contaminants in Ghana (Asante *et al*., 2007, Obiri 2007, Kortasti *et al*., 2008; Boadi*et al*., 2010). In their findings, sparingly it was evidenced that most boreholes in mining areas have high concentration level of trace and heavy metal exceeding the WHO limits.

However, the UNEP and GEMS (2007) have argued that the major problem associated with groundwater is the exposure of water to microbial pollution posing risk of illness or premature death to humans and livestock. In principle, water safe for drinking must be free from any disease causing organisms (WHO, 2004). Hence, the WHO identified the greatest human health risk of microbial contamination as being through the consumption of water contaminated by human or animal faeces (WHO, 2004). This is frightening and the need to examine the concentration of bacteriological contaminants in groundwater in the Wa Municipality to ascertain its purity against the WHO standard permissible for drinking. The study though noted interest in the examination of bacteriological contaminants in groundwater but the threat of heavy metals cannot be underestimated. Therefore, in this study the test for *Total Coliform, Faecal Coliform* and *Escherichia coli* were analysed. According to New York State Department of Health (NYSDH, 2011) testing for bacteria is the only reliable way to know if your water is safe. Thus, it is atheistically said “water cannot be judged to be safe or not safe from bacteria infestation unless it is tested to proof if disease-causing organisms are present” (WHO, 2011). Thus, it is from the foregoing background the researchers took interest to assess the concentration of bacteriological contaminants in groundwater in the Wa Municipality of Ghana.

METHODOLOGY

The study was conducted using an experimental research design to test for the concentration of bacteriological contaminants in ground water. Specifically, randomized selection criteria was used in selection of sample units based on their disposition to contaminant. This was done to assess the sensibility outcome of bacteriological contaminants to measure the impact of the treatments in the water samples as influenced by the presence of *Total Coliform, Faecal Coliform, and Escherichia Coli*. As such, an experiment was conducted among three sample groups to include mechanized boreholes (Group A), Wells (Group B) and the GWCL water supply (Group C). These samples were set as an experiment groups and tested for the presence of bacteriological contaminants. Therefore, in testing for each group, the results were juxtaposed against WHO standard of water quality management indicators independently in each experiment. This helped testing for the presence of bacteriological contaminants in groundwater of all samples to assess its risks on the health safety of consumers.

Sampling Site

In order to ascertain the contamination level of bacteriological parameters in the study area, six (6) sites were selected for sample collection after conducting an investigation into the activities in the study area. These include; Konta

(KM1), Jambori (JW1), Jahan (JH1), GWCL reservoir (GW1), Dobile (DM1), and Bamahu (BM1). Below in Table 1 indicates sample sites and designated code and coordinates.

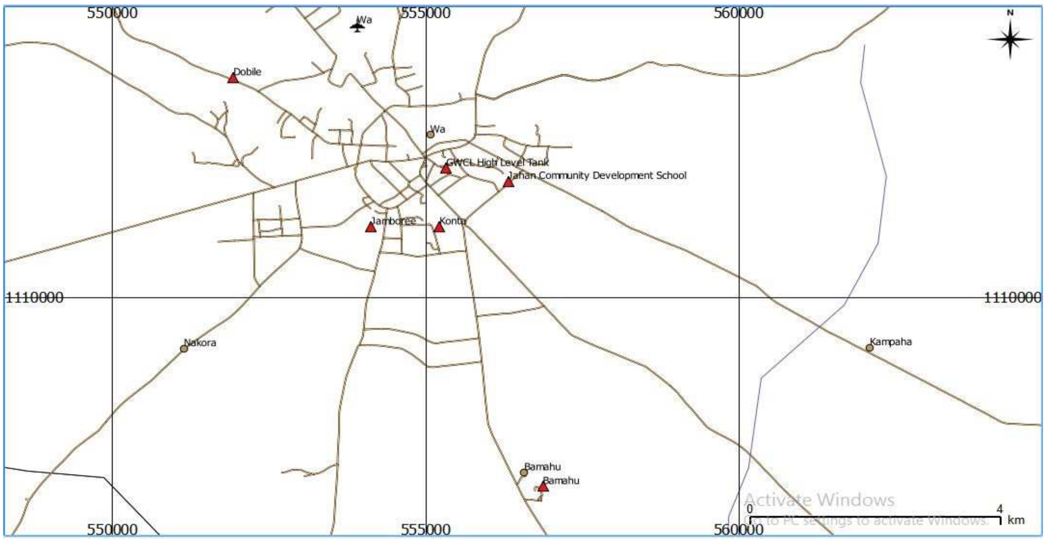
Table 1: Sampling Sites and Coordinates

S/N	Sample Location Name	Water Type	Sample Code	Coordinates		
				Longitude (Degrees)	Latitude (Degrees)	Elevation (M)
1.0	Konta	Mechanized borehole	KM1	10.052	2.496	307
2.0	Jambori	Open Well	JW1	10.052	2.506	300
3.0	Jahan	Hand pump	JH1	10.059	2.486	330
4.0	GWCL-Reservoir	Mechanized boreholes	GW1	10.061	2.495	334
5.0	Dobile	Mechanized borehole	DM1	10.075	2.526	292
6.0	Bamahu	Mechanized borehole	BM1	10.012	2.481	292.5

Source: Author's Own Construct (2016).

Map of Sampling Locations:

The GPS, German 76 model was used for recording the geographical coordinates of the sampling points.



Source: GPS Coordinates Plots (2016).

Figure 1: Map of Sampling Locations

Sample Collection

Water samples were collected in two occasions (June - July, 2016) from three mechanized boreholes, two wells and one from GWCL reservoir within the study area using sterilized bottles. The sampling locations were established in the north-east, and south-west of the study area. A plastic bottle (1 litre) was used to collect the samples after been thoroughly sterilized and rinsed with de-ionized water to get rid of any probable contaminants. These plastic bottles were used to collect the water samples from each borehole and GWCL reservoir at each sample stage for analysis respectively.

Preparations of Samples

The sampling bottles (1 L capacity) were washed and rinsed in dilute nitric acid prior to use. Diluted nitric acid was poured into each sample bottle and shook properly so that the acid react with the metals and some other particles while

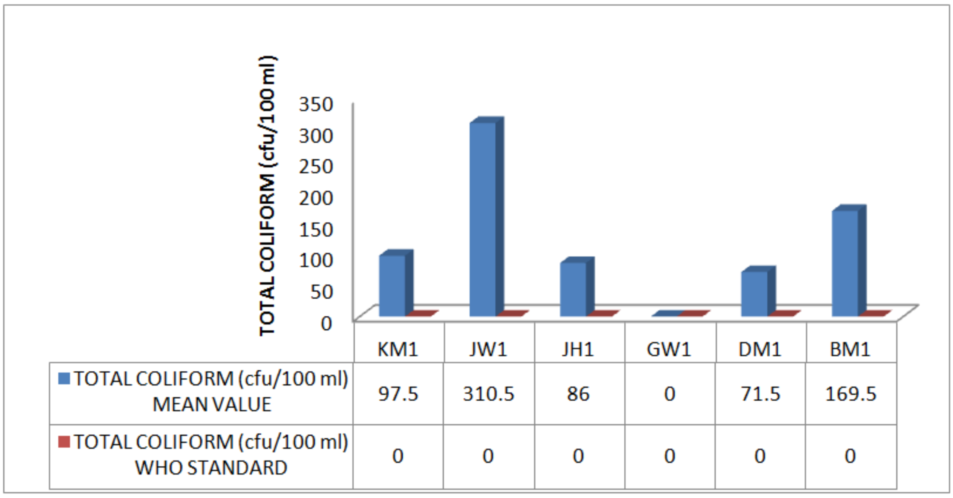
left over night, then poured away the next day. Afterwards, each bottle is rinsed with distilled water so as to get well purified or neutral sample bottles. During sampling, bottles were filled up to the brim, and were analyzed as soon as possible after sample collection by using the membrane filter method (Chromocult Coliform Agar) for the analysis. This relied on the specific colouration of target colonies.

Statistical Analysis

In analyzing the data, statistical analyses were performed using Microsoft Excel (2013 version). Mean values of the parameters were obtained from the field data and were juxtapose with the WHO standard of water quality recommended for consumption. Afterwards, correlation and ANOVA (Two Factor without replication model) were used to establish the relationship and the significance of the existence of bacteriological contaminants in groundwater. The test of significance was tested comparing the F- statistics and $p \leq 0.05$ obtained from the ANOVA table. As such, data was presented using tables and charts.

RESULTS AND DISCUSSIONS

This section analyzed the presence of microbiological parameters and its influences in ground water quality. Below in figures presents analyzed results and the discussed result.

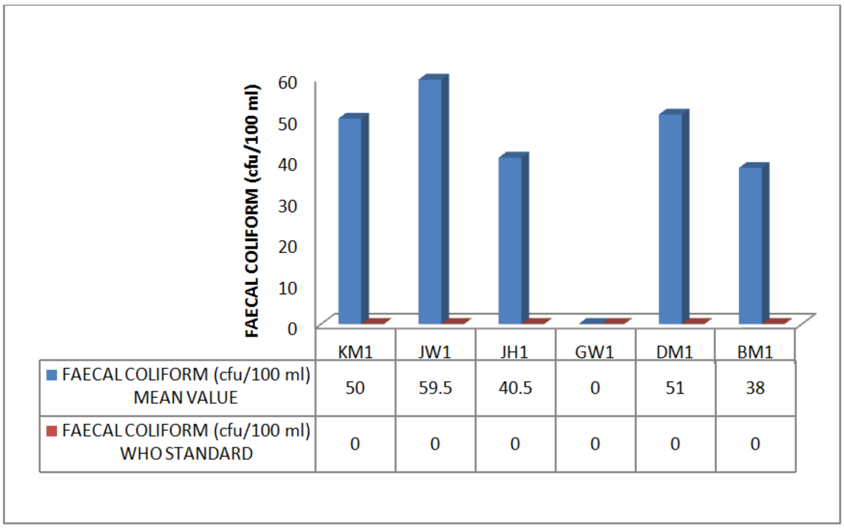


Source: This Study Field Survey, June & July Sample, 2016.

Figure 2: Mean Total Coliform Counts of Water Samples Collected from Boreholes and Wells

Testing on *Total Coliform*, the results showed that with the exception of GW1 (0 cfu/100 ml) which fell within the WHO acceptable benchmark (0 cfu/100 ml), the rest (KM1, JW1, JH1, DM1, and BM1) had their mean values highly beyond recommended values. Among these, JW1 had the highest (310.5 cfu/100 ml), following BM1 (169.5 cfu/100 ml), KM1 (97.5 cfu/100 ml), JH1 (86 cfu/100 ml) and DM1 (71.5 cfu/100 ml) of Total Coliform in that order. This means that with the exception of GW1 the other sample units were highly contaminated with the presence of *Total Coliform* in the water which is dangerous for domestic use and consumption. Therefore, Shittu *et al.*, (2008) argued that, the sources of groundwater contaminated with high *Total Coliform* is influenced through seepage from surface run-off, leaky-septic tanks, pasturing, plant bacteria or natural soil conditions, untreated sewages from treatment plants, infiltration of domestic animal discharge, and contaminated fetching containers. Thus, this study confirm findings by Karikari (2013) who found similar result of 142 cfu/100 ml in boreholes and 293 cfu/100 ml in wells in New Edubiase, the Ashanti Region of Ghana.

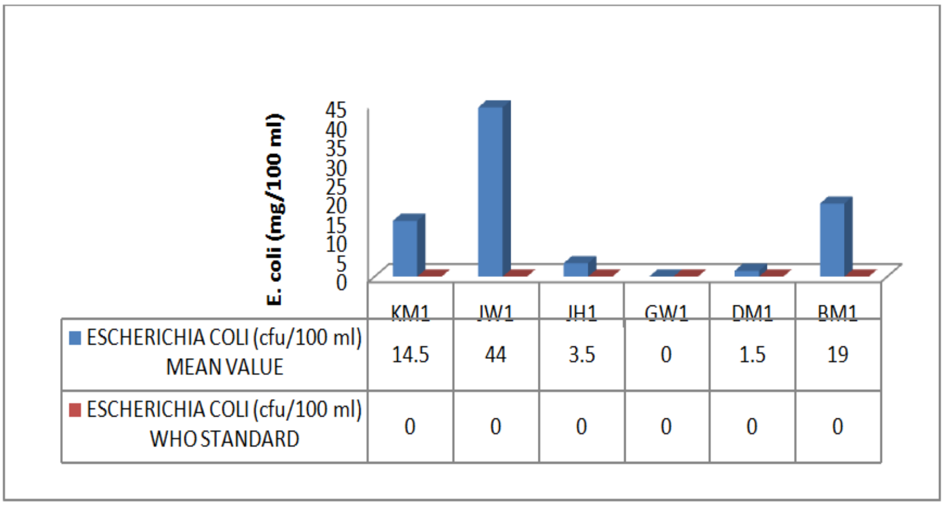
This indicates that wells have high presence of *Total Coliform* in groundwater than boreholes, because the sample unit JW1 had the highest (310.5 cfu/100 ml) which is a well and more so that specific well has no proper lid-cover to protect it against foreign materials entering.



Source: This Study Field Survey, June & July Sample, 2016.

Figure 3: Mean Faecal Coliform Counts of Water Samples Collected from Boreholes and Wells

From **Figure 3**, the results for all the sample units were again above the WHO permissible limit of 0 cfu/100 ml with the exception of GW1 recording (0cfu/100 ml). This means KM1 (50cfu/100 ml), JW1 (59.5cfu/100 ml), JH1 (40.5cfu/100 ml), DM1 (51cfu/100 ml) and BM1 (38cfu/100 ml) have high presence of *Faecal Coliform* in the water and were dangerous for consumption and use if not treated. Therefore, it can be said that apart from the Ghana Water Company (GW1) sample, the others in the Wa Municipality had high concentration of *Faecal Coliform* and thereby poses health threat to consumers. The study of Karikari (2013) also detected the presence of *Faecal Coliform* in groundwater at New Edubiase.



Source: This Study Field Survey, June & July Sample, 2016.

Figure 4: Mean *Escherichia Coli* Counts of Water Samples Collected from Boreholes and Wells

Escherichia coli (*E. coli*) is a bacteria species that normally lives in the intestines of healthy people and animals. The experiment from this study showed that their presence in the sample units were high (1.5 – 44 cfu/100 ml) with the exception of GW1 (0 cfu/100 ml) which met the WHO limit (0 cfu/100 ml). The rest of the samples were above the permissible limit by WHO. Most varieties of *E. coli* are harmless or cause relatively brief diarrhoea, but a few strains can cause severe abdominal cramps, bloody diarrhoea and vomiting. Similarly, Bakobie *et al*., (2015) in their study on the Water Quality Assessment of Hand-Dug Wells in Janga, Ghana, reported0 to 90 cfu/100 ml (*E. coli*). This however confirms the findings reported in this study.

Statistical Analysis on Bacteriological Parameters in Groundwater

Following in this section also presents the statistical analysis on the microbiological parameters in groundwater using correlation and ANOVA: two-factor without replication.

Table 2: The Correlation between Bacteriological Parameters in Groundwater

Parameters	Total Coliform	Faecalcoliform	Escherichia Coli
TOTAL COLIFORM	1		
FAECAL COLIFORM	0.68097	1	
ESCHERICHIA COLI	0.965892	0.569982	1

Source: *This Study Field Survey, June & July Samples, 2016: Two-tail test at alpha: 0.05*

In **Table 2**, the results from the survey showed that there was strong positive relationship between *Total Coliform* and *Escherichia coli* (0.966) but was fairly positive with *Faecal Coliform* (0.681). Also, Faecal Coliform had an average positive (0.570) relationship with *E. coli*. Meaning, the existence of Total Coliform had very strong influence on the existence of *E. coli* and fair on the existence of Faecal Coliform in the groundwater sampled. Similarly, did the presence of *Faecal Coliform* had an average influence on the presence of *E. coli* in the respective sample units.

Table 3: ANOVA: Two-Factor Without Replication on Bacteriological Parameters

Source of Variation	SS	Df	MS	F	P-Value	F Crit
Samples	31728.74	5	6345.747	2.189588	0.13652**	3.325835
Parameters	38681.36	2	19340.68	6.673464	0.014416*	4.102821
Error	28981.47	10	2898.147			
Total	**99391.57**	**17**				

Source: *This Study Field Survey, June & July Samples, 2016.*

*Two-tail test at alpha: 0.05: NB: *Means test is Significant while **Means Not Significant*

In **Table 3**, the test showed that there was high presence of microbiological substances in the sampled units ($p \leq 0.05$) above recommendation but not all sampled units had their mean values beyond the recommended WHO benchmark ($p \geq 0.05$). Meaning there was a significant effect of high presence of microbiological contaminants to which include: *Total Coliform*, *Faecal Coliform* and *E. coli* in some sample units tested in the Municipality.

CONCLUSIONS

Based on the findings, it was evidenced that with the exception of the Ghana Water Company sample (GW1), all the other sample units selected had high levels of concentration for bacteriological elements in the water beyond the WHO recommendations. This means that consumers of such water have a high chances to being affected with water related diseases. This, the statistical test also proved that, there was high significant effect ($p \leq 0.05$) of microbiological parameters in water samples of the study area and require due treatment.

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